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ABSTRACT

Activities originally designed to teach third-grade students about measuring liquids are presented. Included in the document are reasons to teach students how to use the basic units of liquid measurement and the development of a "laboratory" within the classroom where pupils could work while minimizing the mess. Some of the topics developed for small-group directed water-pouring include: (1) comparing volume; (2) ordering containers by size; (3) the "double" series of standard measures; (4) naming the standard measures; and (5) the base two system of numeration. The document concludes with suggestions for evaluation and a list of other materials and activities for non-liquid measurement. (MP)

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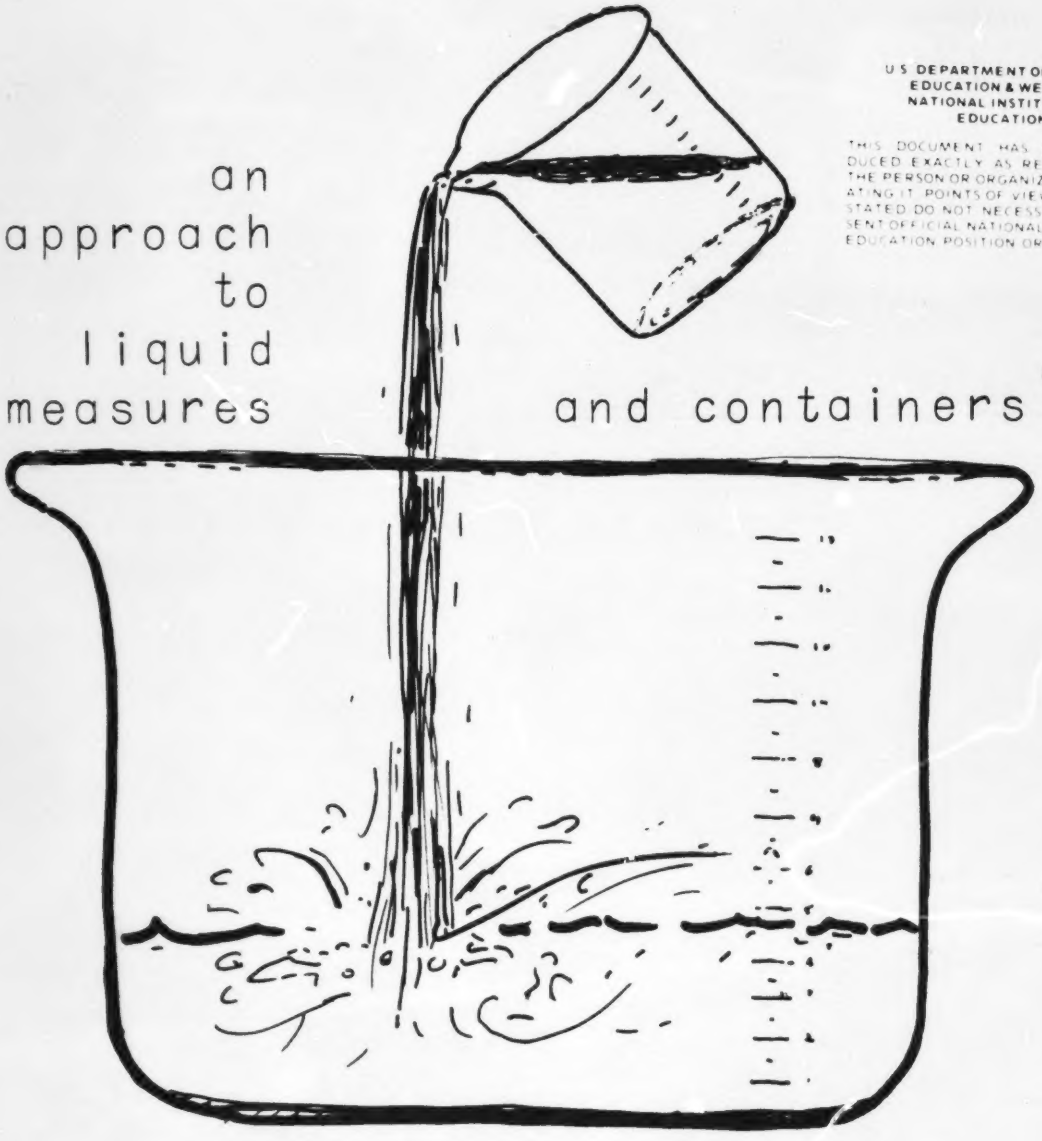
WATER POURING

an approach to liquid measures and containers



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WATER POURING

A first version of "Water Pouring" was prepared in 1967 by the actual teacher, Tamara Rasmussen, with the help of Gloria Bush, Learning Centers Project coordinator.

In the summer of 1972 the following team prepared the present version: Julia Hirsch, mathematics; Esther Cristol, general editing; Lore Rasmussen, general editing; Bette Greenwood, art.

WATER POURING

An Approach to Liquid Measures and Containers

Introduction: The Gist of Liquid Measures page 3

I. Some Trepidations page 5

II. Facilities and Materials Needed

A. The creation of "water-island" page 7

B. Equipment page 9

III A Question of Policy

A. The "discipline" of science page 10

B. Academic freedom page 11

C. The spirit of the thing page 12

IV. Topics for Small Group, Directed Water-pouring

A. Comparing volume page 14

B. Ordering containers by size page 17

C. The "double" series of standard measures page 19

D. Naming the standard measures page 21

E. Base two system of numeration page 25

V. Evaluation

A. Intuitive teaching page 27

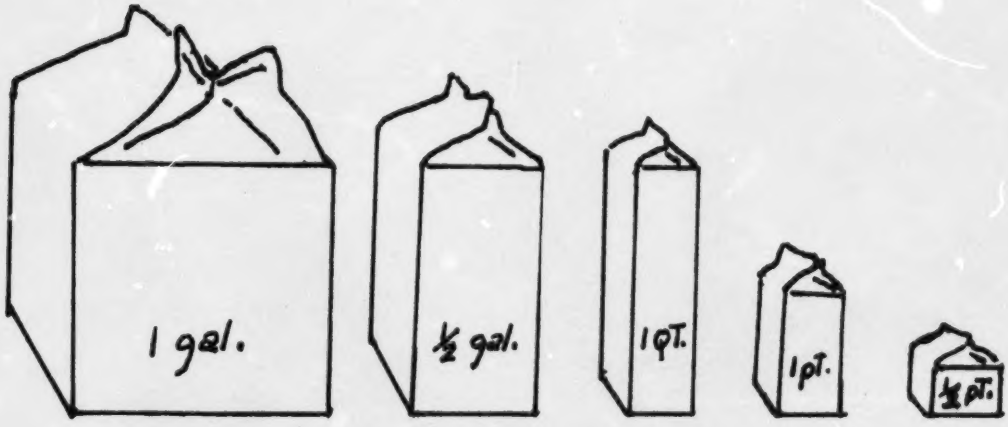
B. Suggestions for a more rigorous evaluation page 28

VI. Other Materials to Use page 29

INTRODUCTION: The Gist of Liquid Measurement

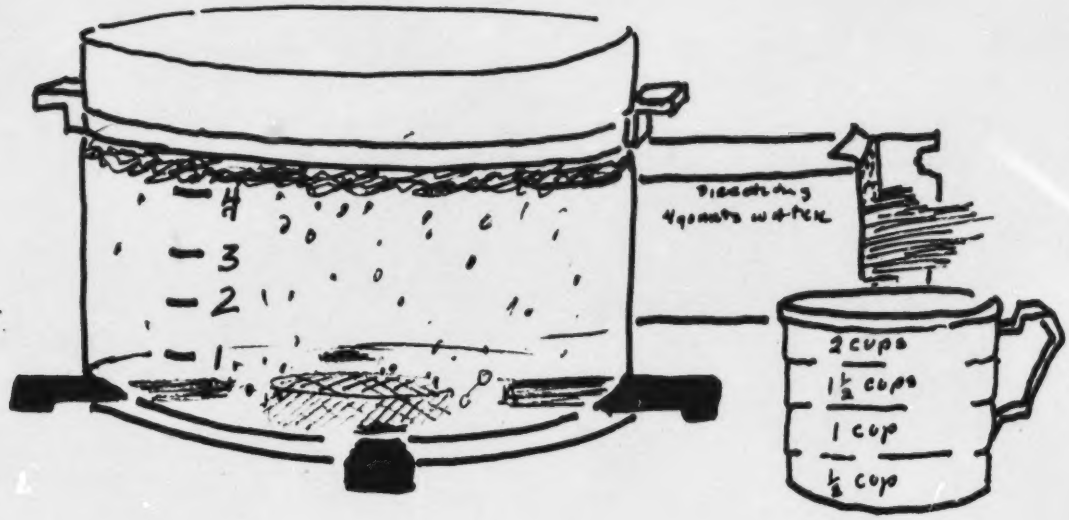
The gist of what "liquid measurement" is all about could be stated frankly like this:

> These are the only sizes of containers that milk comes in at the store. You can get each of these 5 sizes in either glass or plastic bottles or waxed cartons.



Most containers made to hold liquids are in these same five sizes, even when they look different. The containers are made so that each size is twice as big as the next smaller size (and so, ½ as big as the next bigger size). If you check this yourself at home by pouring, be sure to fill the containers only as full as they are when they come from the store - and remember: it's hard to pour exactly.
The sizes could have been given any names but everyone calls them by the same names to make it easy to talk about how much there is inside.

Introduction



O.K. - if it's just that short and sweet. But drawn out into a unit on liquid measures, it's boring and incomprehensible. I hated the idea of teaching liquid measures to third grade children. Of course, I could think of reasons why they "needed" to learn it:

1. So when the recipe asks for 4 cups, they know they'd better not drink part of their last quart.
2. So when the spaghetti box says 4 quarts of water at a rolling boil, they use a pot big enough to contain both the 4 quarts and the rolling boil.
3. So when the ad says 1 quart for 45¢ and an economy half-gallon for 89¢, they can judge whether saving 1¢ is worth dropping the too heavy bag of groceries on the way home.
4. etc.
5. Any way it's a sneaky way to drill them on their 2 X tables.

I. SOME TREPIDATIONS

I know that kids love to pour water and to mess around with wet stuff. But I was afraid of the mess! Afraid of the janitor's look when the water would drip down into his basement office and dilute his coffee... Afraid of the bill when they come to replace my linoleum tile floor... Afraid of the notes from grieving parents accusing me of giving their children pneumonia by making them sit in pools of water and then go out into the cold world with dripping knee socks....

My containers were already collected and my work sheets prepared, but fears like this kept me from plunging in.

What actually gave me courage for the plunge was the creation of "Water Island".

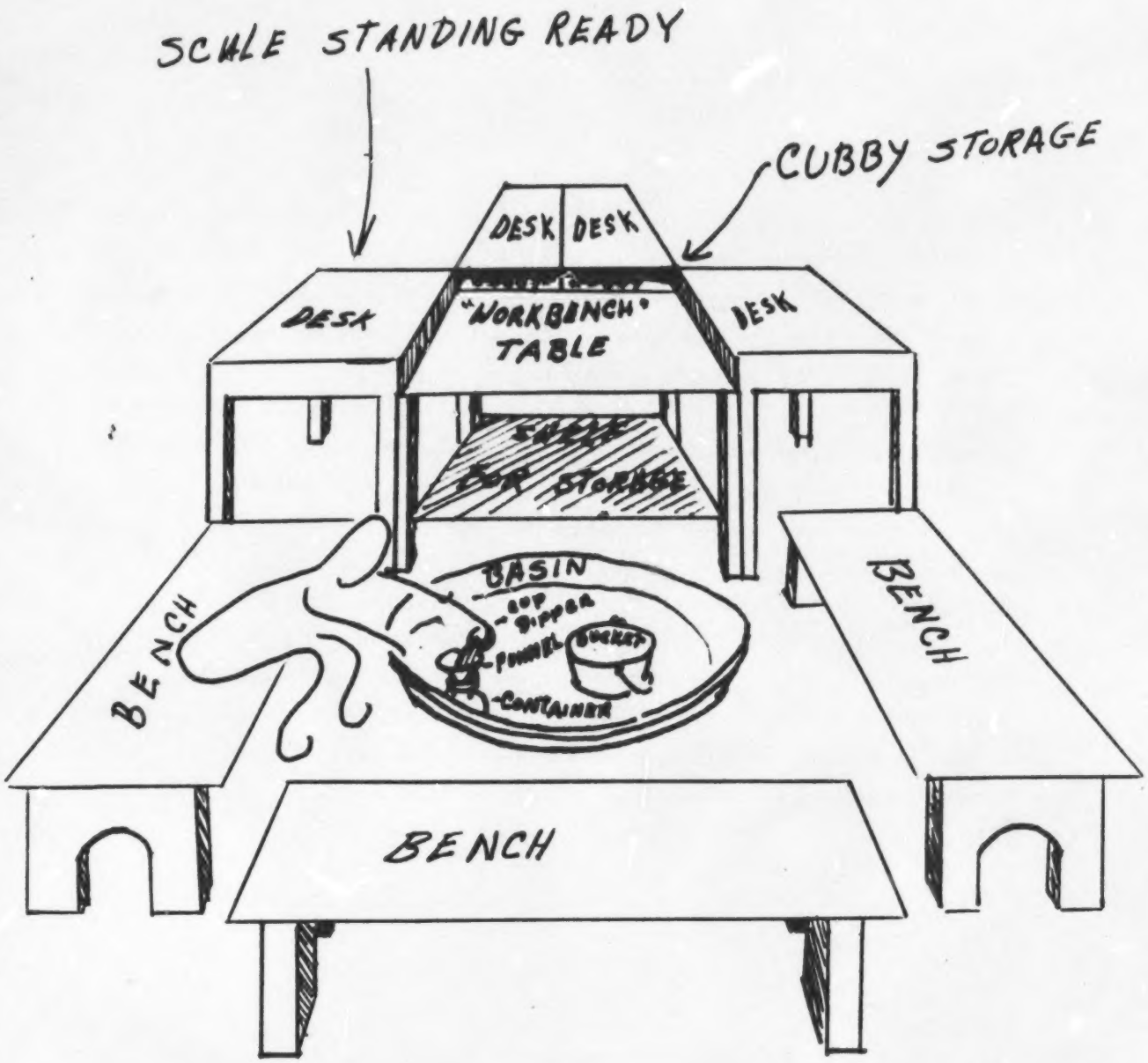
II. FACILITIES AND MATERIALS NEEDED

A. The creation of Water Island

My creative bosses, Lore and Gloria, had been helping me to rearrange my room, and Lore had discovered an unusual arrangement of furniture that provided a split level working area with storage space. The area was somehow attractive, inviting and secluded, roomy, but all within reach. (Note illustration on the next page.)

Four desks fit around the wooden "workbench" table so that the storage space under the desks opened exactly at the level of the work table surface. The work table had a shelf underneath that pails could fit on easily. Three little benches made the other sides of the square enclosure where our basin containing a bucket and containers stood.

By sitting on the benches we were able to pour from above which gave us greater control. "Water Island" in its dryer moments proved useful as a puppet theater, a boat, a bus, a house, a store, and a safe place to build with blocks or Cuisenaire rods.


SCALE STANDING READY
CUBBY STORAGE
DESK
DESK
DESK
DESK
"WORKBENCH"
TABLE
SCALE
FOR STORAGE
BASIN
SCOOP
DIPPER
FUNNEL
BUCKET
CONTAINER
BENCH
BENCH
BENCH

B. Equipment

For each group pouring you will need:

- A water supply: two buckets each about 3/4 full.
- A large basin for pouring over to prevent spilling; (a small child's wading pool or tub would serve the purpose.)
- A pouring area, with the equipment accessible, arranged so the group can sit around the pouring basin. Pouring is easier if the child is sitting a little higher than the containers.
- A wide-lipped funnel
- A number of large sponges
- Many containers:
    1. the majority fitting the standard liquid-measure scheme of pints, quarts, etc., and including two paper milk cartons in each of the following sizes:

        gallon
        ½ gallon
        quart
        pint
        ½ pint (cup)

    2. several containers in various odd sizes and shapes, such as plastic milk containers, ice cream cartons, bleach bottles, refrigerator dishes, mayonnaise jars, peanut butter jars.
    3. various size drinking cups and tumblers.
    4. several kinds of standard measuring cups.

Note: If children donate containers, remind them to wash them out well at home. Also, a produce scale within reach and familiar to the children is thought provoking.

Caution: No glass containers or bottles.

III. A QUESTION OF POLICY:

A. The "Discipline" of Science

Because of my fear of bacchanalian revels with the water, I initiated the whole activity as "scientific research" under my close direction. Care in both measuring and pouring was stressed. No drops on the floor was a goal, although we were good-natured about occasional spilling. (No sense in adding tears to the deluge!)

The children were painstakingly careful with surprising success. The care taken seemed to add drama rather than lessen enthusiasm. The basin I used gave minimal protection. It kept the water off the floor - if pouring was very careful.

Later a 2' by 6' galvanized planting table arrived that would enable many children to pour at once, but I think things were more controlled, yet held the children's interest well, with only one person pouring at a time. And I think the intimacy of the island set a valuable tone.

B. Academic Freedom

Once I had set the tone of "scientific research" to limit the gay abandon of the proceedings, I found that I had forced myself into the position of having to respect interruptions. "I wonder if....I think that.... I guess that....I betcha...." This groping had to be encouraged. When the question was "Can I test it now? Can I try it now? Can I see it?....Can I pour now and find out?" I had to make every effort to answer: Yes! Every apparent confusion, every question, every verbalized hunch had to be discussed, tested. In this way the produce scale was spontaneously brought over by the children to answer the question: "But

will double the water weigh two times as much?" What we ended up with was not so much a scientific consideration of water-pouring as a refinement of our ability as a group to consider any problem scientifically.

As this unit developed, I became more and more convinced that its greatest value was in the general spirit it developed rather than the specific concept involved. I came to see my basic goals in terms like these:

Before class	During class
To create an environment rich enough to stimulate enthusiastic interest yet structured enough to direct children into creative problem-solving activity. To minimize the need for teacher's direction and encouragement.	To encourage the group in their development toward a scientific approach or attitude, a creative "problem-solving" style of thinking and learning that would be fruitful in dealing with any concrete situation. Where necessary to direct group thinking in an effort to develop ability for self-direction.

C. The Spirit of the Thing

During the 1st lesson Acey "didn't want to play", and I said nicely that he could do something quiet if he didn't want to play water-scientist with us today. Tony gave me a long look and said - "I want to play with Acey". I said he could. Both sat by the gerbil cage and drew pictures of the gerbils. None of the other children wanted to "drop out". A visitor to the class was scandalized that I hadn't forced

the boys to participate. "They need measurement so much."

When they said that they didn't want to play they were measuring the limits of the playful spirit of my room. It would have spoiled the game for the others to have made them. I'd like one limit in our room to be not spoiling the learning game for the others - a limit for me as well as for the children.

IV. TOPICS FOR SMALL GROUP, DIRECTED WATER POURING

Topic A - Comparing Volumes

Procedure

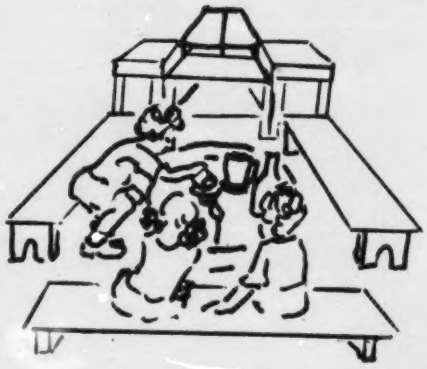
Only a few containers are needed for this, but choose them so that the relative sizes are not too obvious. Plastic bleach bottles and ice cream packages make tricky comparisons with milk cartons.

Each child forms a hypothesis.

Big can mean many things, (tall, fat, grown-up..). In this situation we consider big to mean holds a lot. We try to determine which of several containers holds the most. Who would choose a glass of ice cream soda which didn't clearly hold the most? But is it always clear?

Teacher-Pupil Interaction

Sitting at Water Island with several children, we examine the array of containers in the center. "Let's try to guess which of these containers is the biggest. Who wants to guess first?"



"Now wait a minute; everyone seems to have a different idea. Marilyndia, what makes you think this one's the biggest? ... And why do you think this one is, Derrick?"....etc.

"Well, what if we mean containers full of ice cream for you and your best friends? These are all containers for holding something wet. Which one do you think holds the most? "

Topic A

Procedure

A practical question, Children notice and mention:

- the fold of the milk carton (when folded down, it may spill if filled over the fold line.)
- a line near the top of the plastic containers
- a red line on a measuring bottle
- the dilemma of "filling and spilling". (Its easier to pour if it's not filled to the very top.)

An unopened milk carton from the cafeteria may help to settle arguments about how full is full in regard to opened milk cartons. To avoid controversy, the full line may be marked ahead of time on other types of containers, by taking a trip to the market and observing the levels of the different liquids.

Teacher-Pupil Interaction

"Let's fill up this big one and see if all the water fits into this other big one. Do you guess that it will? Who guesses that it won't?" (No discussion of counting dips as yet, although some children do this spontaneously.)

"How full is full? Where do we stop? Where does the milk come up to when you buy it at the store? Does it come right to the top? How full does the carton come?"

"If you brought home a container from the store and opened it up and there was that much milk would you feel cheated?"

"Would you want to bring it back? Or would you think it looked O.K.? Does it look 'full' the way it's supposed to be? What do you think, Terry?"

Since we are not too sure about <u>exactly</u> full, let's just

Topic A

call them "about the same" when we can't decide quickly which is bigger.

Procedure

We're ready to test the various hypotheses about which is the bigger container. If water spills over, then the pouring container is the bigger. A child who doesn't immediately see this may not yet understand that the amount of water remains the same when water is poured from one container to another (conservation of volume). Send him off for free play with a batch of "about the same" containers.

Teacher-Pupil Interaction

"Waterfall pouring" - biggest to smallest (leftover water - why is some left over?)

"Is anybody surprised with what we found? Did any of the containers fool us?"

Topic B - Ordering Containers by Size

Procedure

We all agree now that biggest means "holds the most."

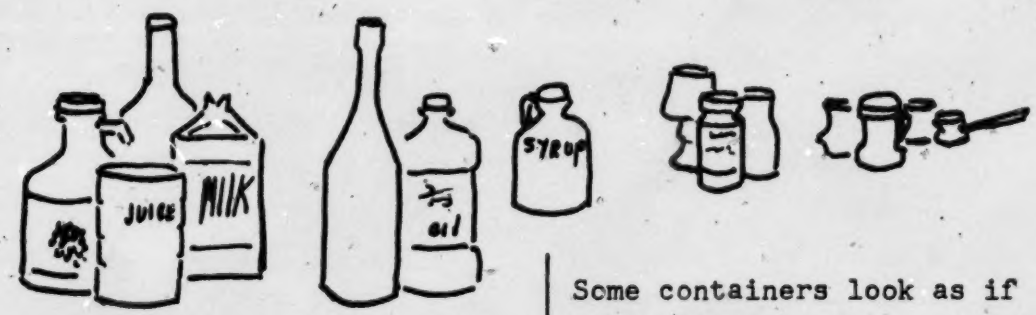
Objects can be ordered by volume. If A holds more than B and B holds more than C then A holds more than C. (Transitivity)

A rough <u>hypothetical</u> ordering is established by the children on the basis of volume (how much it holds). All hunches are respected. Disagreements wait to be solved and hypotheses wait to be <u>tested by pouring</u>.

Teacher-Pupil Interaction

While (8) others are occupied with independent activities, I sit with (8) volunteers around the water basins and containers. "Let's make a parade of containers biggest at one end, then next biggest, all the way down to the littlest at the other end."

To forestall grabbing: "Tony, you try first, and then we'll see what other people think The children take turns shifting the order, with involved disagreement and uncertainty.



We've formed our hypothesis.

Some containers look as if they would hold about the same amount. The group of "about the sames" fanned out on the sides of our parade of "holds the most to holds the least" containers.

Topic B

Procedure	Teacher-Pupil Interaction
We test the hypothesis.	"Well maybe one of those <u>does</u> hold the most. Maybe you're all right - maybe it does take more to fill those than to fill the others. Let's pour and see!"
	Pouring begins.
	"This one's not in the right place." "Well, where do you think it belongs?" New guess - more pouring until we find its place.
	Finally we are sure our parade is correctly lined up.
	"Now let's mark them so we remember what we found."
Some containers may be standard sizes, some not. At this point we ignore this since we are interested only in the relative volumes.	We used the letter A or the numeral 1 for <u>smallest</u>, B or 2 for the next, etc., <u>on up to biggest</u>. (Same notation for "about the sames".)
Beware of forcing closure too soon on labeling the containers.	The notations were made with felt pens on strips of masking tape attached to the containers.

Topic C - The "Double" Series of Standard Measures

Procedure

Containers have been chosen (see "Equipment"-page 9) so that the "about the sames" are the cup, pint, quart, half-gallon and gallon containers.

Concept: unit of measure
the smallest size container serves as a unit. When we guess "how many" will fill another container we are estimating the volume of the second container in terms of the first.

Vocabulary:
Double means twice as big.

> Seeing double,
> double-trouble,
> double-dip ice cream
> cone, double-letters,
> "double-good double-
> mint gum!", double-
> u.

The big one is double a small one.
The big one is twice as big.
The little one is ½ as big.
(different shapes, same size)

Teacher-Pupil Interaction

Ask the children to take the groups of "about the sames" and put the groups in a size parade. Repeat the pouring activity if there is any difficulty.

"We all have these together in one group because they all hold about the same; it takes about the same to fill each of them."

"Now let's guess, how many of this size full will fit into this-roughly now, let's not be too fussy, just so it's full enough so that you don't feel cheated."

"About how many times does this one go into that one?"

Guessing before testing should be stressed continually. Children enjoy thinking this way. Scientific thinking is game-like to a child. (and to a scientist?)

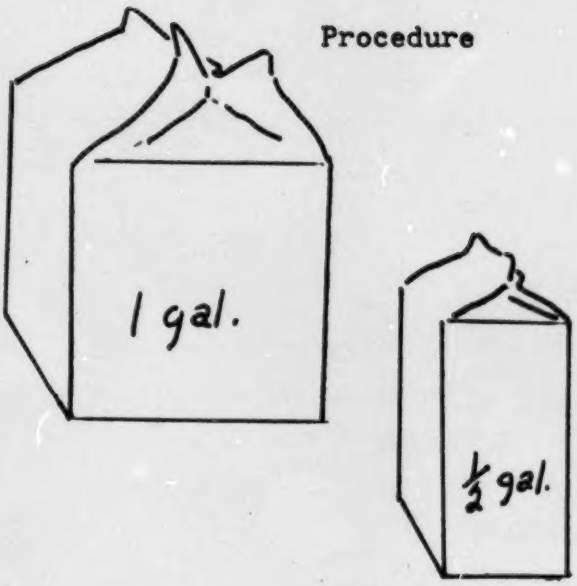
Like milk containers our groups fit a double-system.

(Children are pouring)

"This group is double that

Topic C

Procedure



Extending the doubles series downward.

Teacher-Pupil Interaction

group - is the next bigger group double again? Can we make a doubles parade?" (Watch to see if the children seem ready to talk in terms of multiplication and division - I wouldn't force this, yet.)

Since the children are now used to thinking in terms of approximation, the double-system is recognized and accepted (discovered if you will) naturally by the children, not imposed by the teacher.

Optional:
"Is there anything in the room that we can double to fill the littlest milk container? The metal ½ cup measure will. The metal ¼ cup measure (or our plastic tea set cup) can be doubled to fill the ½ cup measure."

The real names of the containers may be introduced here.

The children "saw" the ½ and "quarter" relationships before they had to learn the names.

Topic D - Naming the Standard Measures

Procedure

Cup is a common English word. Cups come in all sizes. The paper cup, flattened holds nothing at all. The more you open it, the more it holds.

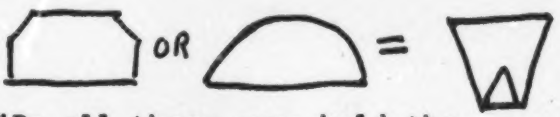
"Cup" is also the name of a special size of container. A "cupful" means one standard measuring cup filled to a standard mark.

Teacher-Pupil Interaction

(Collection of cups)

"What do we call this and this?"

We call all of these things cups. If I were thirsty and there was a sink, I could fold paper like this, and if I drank from it quickly I could use it as a <u>cup</u>.



"Do all these cups hold the same amount of soda? If you liked soda which cup would you want me to fill for you? Which cups hold about the same amount?"

<u>Guessing Pouring to see</u>

This metal cup is a standard cup or a measuring cup. It has 1 cup written in the bottom. This metal cup is a measuring cup too. This little line at the top shows where it is full and says <u>one cup</u>. This is a glass measuring cup. Filled to the line the glass one fills the metal one (meant for sugar)

Topic D

Teacher-Pupil Interaction

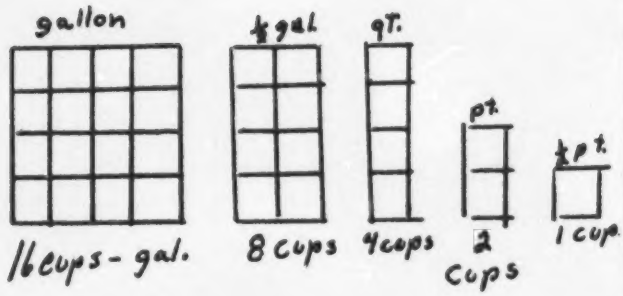
to brimming. It takes the same amount of water to fill both to where it says 1 cup.

If you go to a store and ask for a measuring cup you always get one that holds just this much.

When a recipe says 1 cup of sugar or milk it doesn't mean this little drinking cup or this big drinking cup - it means one measuring cup of sugar.

Topic D

Procedure



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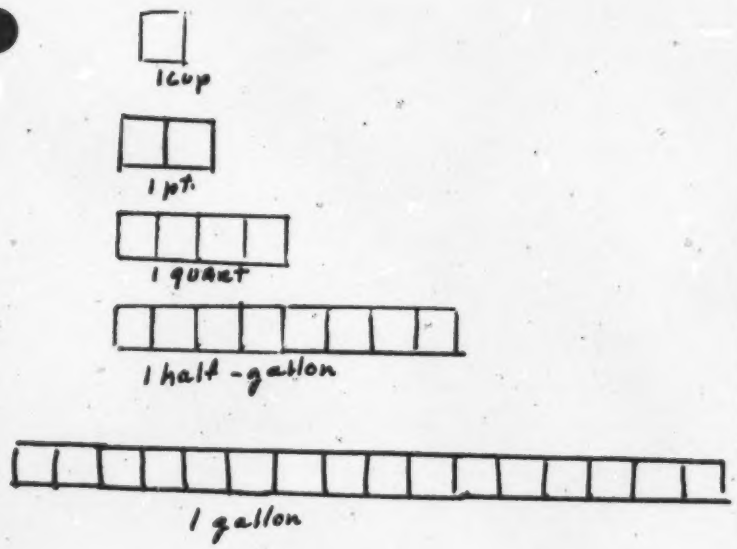


Teacher-Pupil Interaction

Children can now trace or draw representation of the containers to make a chart: Here the teacher can have a big chart already made, or make one on a grid on the board. But each child should make one for himself on graph paper.

"Let's make a picture of how the sizes compare." On your graph paper (¼ inch squares) outline one square on the right side of the paper. Let that stand for the littlest size. The next bigger size is 2 times as big so outline 2 squares to the left of the one square.

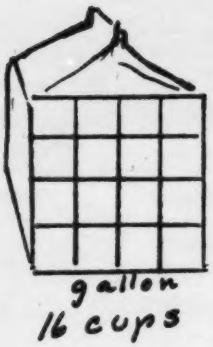
Draw pictures of each of the sizes. The biggest picture, on the left of the page should be 16 squares.

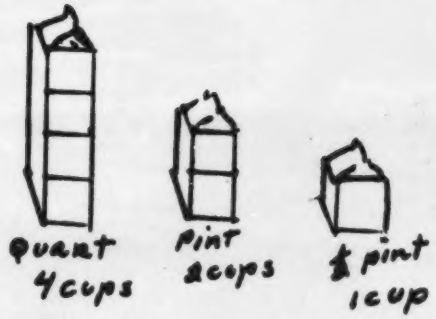
Why?

Topic D

Procedure

Method:
Pour again to find out or predict. The doubles system makes prediction possible, (2 cups fill a pint; 2 pints fill a quart; so 4 cups fill a quart) so pouring isn't really necessary, except to check the prediction.





Teacher-Pupil Interaction

"Which of our cups are about the same as a measuring cup?"

Measuring the sizes of the double parade in standard cups:
"How many cups does it take to fill each size of 'about the sames'?"
(Have several different children measure the same size to check accuracy.)
The smallest size is about 1 cup. The next size is double so it should be about 2 cups - but pour to check! etc., all the way up.

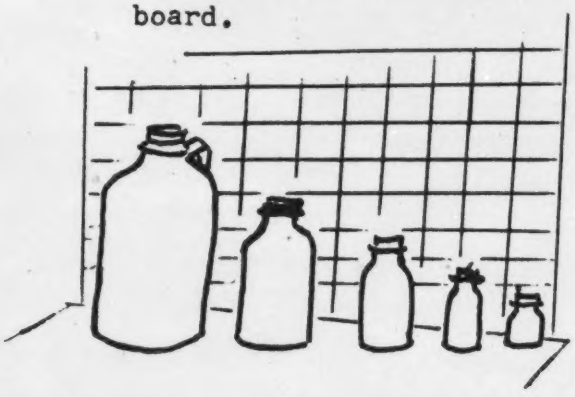
Now is the time for 2+2 = 4, and "How many of these (4) go into this (16) ?"

Replace the letter or number names with the real names of containers written on masking tape.

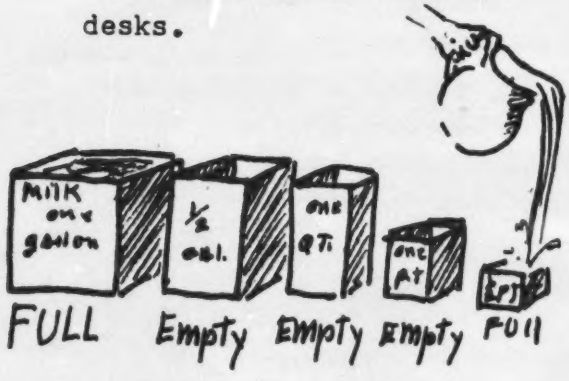
Topic E - The Base Two System of Numeration

Procedure

"Doubles" parade of containers standing in order (biggest to visual left of children) in front of big chart on paper or blackboard.



Children each have graph paper chart and tiles, or white cuisenaire rods at desks.



Teacher-Pupil Interation

"The store only sells full containers, and we want to carry home as <u>few</u> containers as we can. We also don't want any left over."

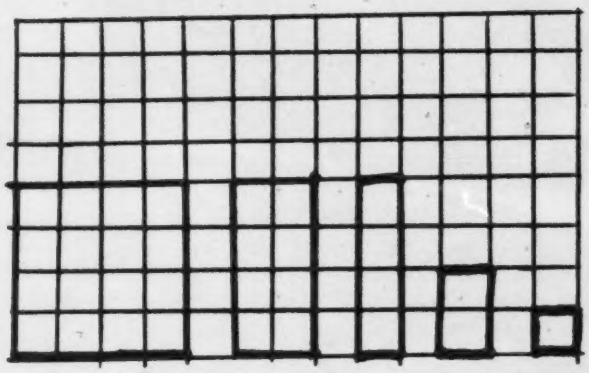
"Mother says buy me exactly 17 cups of milk. What containers should I bring home?

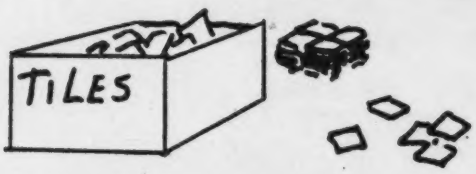
Let's pour!

Try filling the biggest first. Will 17 cups fill the biggest one? How many times? What is left over? Will the left over liquid fill the next biggest container? How about the next?"

Topic E

Procedure

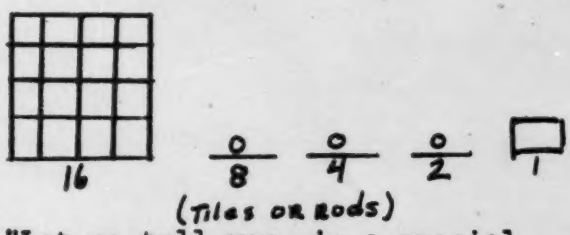




To write a base numeral for a number, we break down the number into a sum of 1's, 2's, 4's, 8's, 16's, etc., (and not more than one of each) just as to write an ordinary base ten numeral we express the number as a sum of 1's, 10's, 100's, 1000's, etc. In deciding on the smallest number of cartons to bring home, a child is doing just this. 10001 is the base two numeral for 17.

Teacher-Pupil Interaction

Make a picture on the graph paper with tiles. Fill up the two places we need. These are the fewest containers we can buy to get 17 cups of milk.



"Let me tell you, in a special code, what containers we bought:

1 0 0 0 1

Can you figure out what my code is?"

"Right. Now, suppose two boys come back from the store. Jay has

0 1 0 0 0 cups of milk

and Bobby has

0 0 1 1 0 cups of milk.

Who has the most?

Jay - here's why:

01000 = (0 X 16) + (1 X 8) +
gallon ½ gallon

(0 X 4) + (0 X 2) + (0 X 1)
quart pint cups

So Jay has 8 cups of milk.

V. EVALUATION:

A. Intuitive Teaching

To teach intuitively, relying for an evaluation of success or failure on a feeling in the pit of the stomach (presumably independent of one's breakfast or mood) is in many eyes not enough.

I have a few suggestions for rigorous evaluation to offer at this point - but your subjective reaction is perhaps as relevant as anything.

Watch the children in a small group "messing around" with a creatively prepared situation rich in possibilities, before the "lesson", when the teacher begins messing around with them. An observer might as well go out to get a cup of coffee during the "teaching", though he or she is welcome to stay.

With that initial impression of the children (their ability to relate to their environment and to each other in an intellectually productive manner) still in your mind, come watch them "messing around" in a new but comparable situation later - after a lesson or a year of lessons.

I would hope that you would see, in a greater degree than mere cumulative experience could account for, zestful curiosity; playful interest in "guessing and then testing"; verbalization of ideas; consideration for the ideas of others; awareness of confusions and problems; open and creative search for strategies; concern for accuracy and appropriateness; and sustained, concentrated self-directing activity.

B. Suggestions for a More Rigorous Evaluation

To what degree was what I tried to teach actually learned?

or

How can I measure my actions in relation to my goals?

Procedure	Teacher-Pupil Interaction
Choice and preparation of materials and facilities.	What did the children need from me that I was not prepared to give or failed to give?
What did I forget?	What did I "give" the children that they might better have "got" by themselves?
What were the children unable to make full use of and why?	Did I end up "teaching" something of value that I did not expect to?

VI. OTHER MATERIALS TO USE

Macaroni, buttons, etc. for sorting by size.

Clay, sand for helping children to see that change of shape doesn't mean change of volume of a solid object.

Cuisenaire rods, tiles, paper squares for doubling and units of measure.

How many white cuisenaire rods make up each of the other colors?

How many white rods equal this multicolor house in amount of wood?

How many red rods equal the amount of wood in that same house?

How many little square tiles make up other tiles?

Money for a base ten game.

"Assemble 397¢ in the fewest pieces of money.":

$10 bills	$1 bills	dimes	pennies	(up to $100)

or "Assemble 87¢ in the fewest pieces of money.":

quarters	nickels	pennies	(up to $1.25)

Beads and bottles for another base ten game:

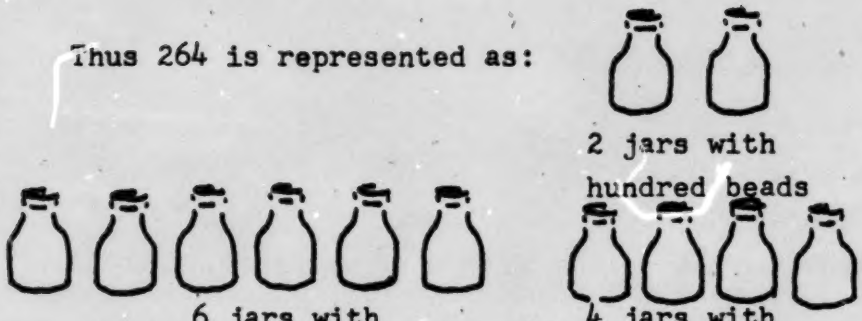
"Can't open" bottles of beads or beans:

so that you can add and "trade in."

one	"1000 bottle"	
six	"100 bottles"	needed
18	"10 bottles"	supplies
18	"one bottles"	

Rule: use fewest bottles -- trade in whenever possible.

Thus 264 is represented as:



2 jars with hundred beads

6 jars with ten beads

4 jars with one bead

The bottle should stand on "place square" to show empty places when a size of bottle isn't needed.

Dienes multibase blocks for developing base two, base ten and other systems of numeration.

Mathematics Laboratory Materials by Lore Rasmussen

work sheet U 7-10
T 13-30
M 17-21, 23

Children in your classroom.

Who in the class comes closest to having a standard foot?
(Animals, desks, poems have feet, too.)
A yard was measured from nose to fingertip.
Compare the measures of individuals with a yardstick.

Please return to: "Teacher to Teacher"Editor
Learning Centers Project
Durham Child Development Center
16th and Lombard Streets
Philadelphia, Pa. 19146

QUESTIONNAIRE: WATER POURING

1. Would you want to use this booklet in your classroom (or with the teachers with whom you work)? If not, could you explain why?

2. How would you use this booklet? (a) Give to teachers? (b) In combination with in-service training? (c) Pre-service training? (d) Reference library? (e) Other?

3. Do you now use booklets like this? If so, how would you compare the usefulness, attractiveness, and readability of this booklet to those now available to you?

4. Are there <u>other</u> subject areas you would like to see covered in similar materials? (We have other teacher-writings in process which might fit your needs.)

THANK YOU FOR YOUR ATTENTION TO THIS QUESTIONNAIRE.